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VARIABILITY IN GROWTH OF POSTLARVAL *PENAEUS VANNAMEI*

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ABSTRACT This note reports the average size of *Penaeus vannamei* postlarvae held under a variety of conditions for approximately 30 days. Fifteen separate and independent rearing trials were completed over several seasons. Extreme growth variations were noted, with significent differences existing in eight of the 26 replicates. Significant differences were noted for treatments in seven of the 12 studies. Shrimp ranged in size from an average of 0.01 to 3.08 g after a month of culture.

Introduction

Commercial aquaculture in the Americas typically involves culture of the South American white legged shrimp, *Penaeus vannamei*, in earthen or plastic-lined nursery ponds (Sturmer and Lawrence 1987). Postlarvae stocked into nursery ponds are expected to achieve a 1 g size in 30 to 45 days. After this nursery period, the juveniles are stocked into large earthen growout ponds.

The use of nursery ponds increases the feed efficiency for the postlarvae and provides better inventory control for the stocking of production ponds. Extending the growing season is one advantage of using nursery ponds in the United States. During the colder months, shrimp culture may be started indoors under controlled conditions. At the Gulf Coast Research Laboratory (GCRL), rearing trials of postlarval *P. vannamei* were conducted under a variety of conditions. Results of those independent trials are presented here.

Materials and Methods

P. vannamei postlarvae obtained from a number of commercial and research hatcheries in the United States and abroad were reared at GCRL. Most studies utilized 113 L, all-glass aquaria stocked with 30 animals each (108/m^2). Several 1.5 m diameter by 1.5 m deep kalwall tanks (Solar Components Corp., Manchester, New Hampshire), rectangular tanks (0.96 m x 1.9 m x 0.3 m) 1.84m^2 and a pond (683 m^2) were also used in some of the studies as noted. Shrimp were stocked at densities ranging from 100/m^2 to 4,000/m^2.

Outside studies utilized aquaria or tanks exposed to full sunlight. Tanks placed under a roofed porch received indirect sunlight. With the exception of one location study in a shed, aquaria maintained indoors were routinely kept at 28°C under constant light supplied by six 40-watt fluorescent bulbs. One study used additional 30-watt lighting directly over each aquaria and *Fucus* sp. algae. Another study used 15-watt lighting over each aquaria and *Gracillaria* sp. algae. Illumination provided by six seven-watt bulbs of three colors (red, green and blue) and a combination of the three colors were utilized in one study. The aquaria were wrapped in black plastic to shield them from incidental light. A study on substrates used five plastic screens suspended longitudinally in each of three tanks, while *Gracillaria* sp. algae was used as the substrate in three additional tanks. A production trial was conducted in a pond containing floating round cages constructed of 500 micron plastic screen with a volume of 1 m^3. A final study utilized three aquaria outside and three aquaria inside plumbed into a common water source. The aquaria were placed in water baths which also shared a common water source. Three additional aquaria indoors were not plumbed into the common water system, but shared the indoor water bath.

Aeration was provided by a single airstone to all treatments with the exception of the pond. A prepared commercial postlarval diet (Zeigler Bros, Inc., Gardners, Pennsylvania) was used in all treatments and shrimp were fed *ad libitum*. All studies utilized water of 16 ppt salinity. Artificial seawater prepared from aged tap water and a commercial sea salt was used in all aquarium studies. Natural sunlight and natural bay water were used in the kalwall tank and pond studies. The postlarvae (PLs), 10 to 36 days old, weighed several milligrams at the time of stocking. After the growth period, all shrimp were harvested, counted and individually weighed to the nearest milligram on an electronic balance. Numbers were averaged and a standard deviation calculated. Significance (α = 0.01) between replicates and between treatments for each study were calculated using analysis of variance (ANOVA). Shrimp growth was expected to increase fourfold after one month. Therefore, growth was not determined in percent increase but reported as final wet weight.

General categories of variability included production, polyculture, light, algae, substrate, source of PLs, feeding rate, water depth and indoor versus outdoor locations.

Results

Growth was extremely variable, resulting in a final average size after 30 days from 0.01 g to 3.08 g (Table 1). Significant differences existed in eight of 26 replicates and seven of 12 treatments. Production trials resulted in sizes of 0.37 (Study A) and 0.10 g (Study N). A feeding trial resulted in a final size of 0.07 and 0.09 g (Study D). Polyculture resulted in sizes of 1.32 (Study E) and 0.28 g (Study F). The use of various colored lights resulted in sizes of 0.04 and 0.05 (Study I). It was interesting to note that the shrimp held under green light turned a deep blue color. The use of a macroalgae substrate and additional light resulted in sizes of 0.14 (Study K) and 0.72 g (Study L). The use of substrate screens resulted in a size of 0.29 g (Study M). Animals obtained from different sources achieved sizes ranging from 0.01 (Study G) to 1.16 g (Study H). The growth at three water depths ranged from 1.02 in the 5 ft depth to 1.34 g in the 3 ft depth (Study B). A comparison of inside with outside growth resulted in an outdoor size of 1.18 g (Study C) and 0.48 g (Study F). Final sizes of shrimp from inside static, inside flowing and outside flowing tanks were 0.81, 0.98 and 1.13 g (Study O). Best growth was recorded for animals held in the 683 m^2 pond (Study J). Shrimp held in cages in the pond reached a size of 1.20 when fed and 1.24 g when unfed. Animals stocked directly into the pond grew to a final size of 3.08 g (Study J). Shrimp in four of the 21 inside treatments (19%) achieved a size of 1 g, while shrimp in eight of the 11 outside treatments (73%) achieved 1 g in size. The maximum size achieved by shrimp in the four treatments held under the roofed porch was 0.47 g.

In the kalwell study (Study B), temperature ranges were similar in the 5 ft (80-96 F) and 3 ft (81-96 F) depth, but fluctuated more in the 1 ft (78-98 F) depth. In the study which compared location (Study C), water temperatures ranged from 73-100, 75-85 and 70-86 F for tanks located outside, under a porch and inside a shed, respectively. In the final study (Study O), the inside flowing and outside flowing aquaria generally maintained the same temperatures, whereas the inside static aquaria generally ranged 2 to 9 degrees lower.

Discussion

The animals placed in natural pond water showed remarkable growth. Leber and Pruder (1988) demonstrated a growth factor present in high density culture systems that promotes growth greater then 1.5 g/wk in production ponds. They showed that this water, when pumped indoors, still induced good shrimp growth. It should be noted that when animals from Study B were harvested and restocked into the kalwall tanks, they also showed remarkable growth, increasing in size by 3.29 g during an 11-day period.

Direct statistical comparisons between trials were not possible due to differences in initial age, tank type, light source, seawater type and temperature. However, empirical comparisons are discussed. For all factors, examples can be found for both good and poor growth.

Shrimp growth is highly variable among groups of animals (Olin and Fast 1989), and even within the same group of animals. While this has been demonstrated by the significant differences reported in eight of the replicates with identical conditions, this is not always the case. Animals from four different sources (two different sources for each study) cultured under the same conditions within the same study achieved poor growth in Study G (0.01 g) and good growth in Study H (1.16, 1.14 g).

Animals cultured outside generally grow better than animals grown inside. Eight of the 11 outside treatments achieved a size greater than 1 g, while only four of the 21 inside treatments achieved a size greater than 1 g. This was contradicted in the polyculture Studies E and F. The shrimp cultured inside in Study E achieved a size greater than 1 g, while the shrimp cultured outside in Study F grew to a maximum size of 0.48 g. However, there was a significant difference in three of the four treatments in Studies E and F. All shrimp were held in aquaria without filtration at a density of 108 m^2 for 30 days. Although there was a difference in postlarvae age at the time of stocking, age does not appear to be the determining factor. The shrimp in Study H surpassed the 1 g size expected in a nursery system while the postlarvae in Study G showed negligible growth even though the animals were twice as old at the time of stocking (PL-12 vs PL-24, respectively). Also, the shrimp in Study H achieved the same size as the shrimp cultured without snails in Study E, even though Study E animals were three times as old (PL-36 vs PL-12). In all three studies, postlarvae were held inside in aquaria for 30 to 32 days at a density of 108 m^2.

In these studies, all treatments that were located outdoors tended to be warmer than the 28°C temperature of indoor tanks. The shallower water depth used for the kalwell tanks also resulted in warmer temperatures. Aquaria placed outdoors tended to grow algae which may have conditioned the water or served as a supplemental feed source. The final study attempted to eliminate the influence of these factors by circulating both the culture water and the bath water. Temperatures and algae growth were the same for both the inside and outside flowing tanks, and no significant differences were noted for shrimp sizes. Significant differences in growth of shrimp in the inside replicates were noted. Therefore, the role of natural sunlight per se has not been demonstrated.

Table 1
Nursery growth of *Penaeus vannamei* under a variety of conditions

Study	Location	Tank Type	Filter	Density /m²	Age PL	Duration Days	Rep No.	Survival Percent	Stat	x Size g	SD
A. production	outside	kal	none	274	20	33-35	3*	39.7		0.37	0.126
B. 5' depth	outside	kal	none	108	26	31	1	19.0	a	1.02	0.338
3' depth	outside	kal	none	108	26	32	1	99.0	b	1.34	0.335
1' depth	outside	kal	none	108	26	32	1	81.0	a	1.14	0.395
C. location	outside	tk	none	100	23	29-32	1	43.8	a	1.18	0.389
	porch	tk	none	100	23	35	1	69.2	b	0.47	0.159
	inside	tk	none	100	23	32	1	51.5	c	0.65	0.248
D. 1% feed	inside	aq	dynaflo	108	14	32	3	68.3	a	0.07	0.061
10% feed	inside	aq	dynaflo	108	14	32	3	85.0	a	0.09	0.073
E. snails	inside	aq	none	108	36	32	3*	96.0	a	1.32	0.357
no snails	inside	aq	none	108	36	32	3	88.0	b	1.16	0.380
F. mullet	outside	aq	none	108	24	30	3*	93.3	a	0.28	0.146
no mullet	outside	aq	none	108	24	30	3*	98.9	b	0.48	0.166
G. source:											
Peruvian	inside	aq	dynaflo	108	24	30	3	82.2	a	0.01	0.019
Guatamalan	inside	aq	dynaflo	108	24	30	3	97.8	a	0.01	0.006
H. source:											
Oceanic Inst.	inside	aq	none	108	12	30	2	88.0	a	1.16	0.548
GCRL	inside	aq	none	108	12	30	2	61.6	a	1.14	0.540
I. lights:											
green	inside	aq	dynaflo	108	--	30	3	67.0	a	0.05	0.040
red	inside	aq	dynaflo	108	--	30	3	76.0	a	0.05	0.027
blue	inside	aq	dynaflo	108	--	30	3	73.0	a	0.04	0.021
mixed	inside	aq	dynaflo	108	–	30	3	75.0	a	0.05	0.033
J. cage/fed	outside	pd	none	108	22	32	3*	73.3	a	1.20	0.542
cage/unfed	outside	pd	none	108	22	32	3	55.7	a	1.24	1.173
pond	outside	pd	none	---	22	32	1	----	b	3.08	0.568
K. bare	inside	aq	none	108	--	30	1	7.0	a	0.02	0.019
with algae	inside	aq	none	108	--	30	1	75.0	a	0.06	0.045
algae/light	inside	aq	none	108	--	30	1	110.0	b	0.14	0.067
L. bare	inside	aq	none	108	--	30	3	90.0		0.49	SNA
with light	inside	aq	none	108	--	30	3	90.0		0.41	
algae/light	inside	aq	none	108	--	30	3	90.0		0.72	SNA
											SNA
M. substrate:											
screens	porch	tk	none	1635	10	37	3*	59.3	a	0.29	0.170
algae	porch	tk	none	1635	10	37	3	52.9	a	0.35	0.218
N. production	porch	tk	exchange	4000	10	30	2	58.0		0.10	0.033
O. static	inside	aq	none	108	12	30	3*	107.0	a	0.81	0.485
flowing	inside	aq	none	108	12	30	3*	58.0	ab	0.98	0.702
flowing	outside	aq	none	108	12	30	3	22.2	b	1.13	0.679

* denotes replicates that are significantly different
treatments sharing the same letter are not significantly different
SNA — sample not analyzed

kal - Kalwell tank 1.8 m² = 5 foot diameter; aq - aquarium 0.279 m² = 3 gal; tk - tank 0.96-m x 1.9-m x 0.3 m; pond 683 m²
inside - 24-h constant illumination; outside - full sunlight; porch - under cover with natural sunlight
Study I used six seven-watt lights (red, green, blue and mixed) with aquaria wrapped in black plastic.
Study J used *Fucus* sp. algae and 30-watt lighting

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